BIOLOGICAL RESOURCES

WILDLIFE

A large number of animals depend on the ACEC salt marsh and upland to forage, breed, rest, and migrate to other seasonal habitats. Much of the Plum Island Sound region is part of the U.S. Fish and Wildlife Service's (USFWS) Parker River National Wildlife Refuge. In addition to the federal refuge, there are also a number of state wildlife management areas and a number of properties owned by nonprofit conservation organizations that help protect wildlife throughout the ACEC. Barrier beaches of Plum Island and Crane Beach along with surrounding salt marsh habitats are especially attractive to birds and other wildlife.

Despite the recognized importance of the ACEC to wildlife habitat, little data exists on biodiversity and historic wildlife population estimates. The majority of wildlife data is collected for bird populations since the area is a well-known habitat along the Atlantic Fly-way Migration route. Over 300 species of birds have been sighted at the National Wildlife Refuge, including 75 rare species (DEM 1993). Numerous shorebirds use the barrier beaches and coastal salt marshes as important stopovers on their spring journeys to breeding grounds in Canada and on their fall journeys to tropical wintering grounds.

As part of the Plum Island Sound Minibay project, historic records of birds in the region were evaluated and compared to current surveys of water birds, waterfowl, shorebirds, gulls, and terns. Historical data was taken from journals of a state ornithologist who kept notes on birds he observed during the 1930s, 1940s, and 1950s. For comparison, results from the early 1990s were analyzed from refuge bird surveys conducted by members of the Brookline Bird Club (Buchsbaum et al. 1996). The analysis (Table 8) examines long term trends and synthesizes baseline data about birds currently using Plum Island Sound for breeding, feeding, and resting.

Table 8. A comparison of historical and present bird numbers on Plum Island (Buchsbaum et al. 1996).

Species	**Comparison trends from 1930-1950s to 1990s**
Common Loon (*Gavia immer*)	Has shown no consistent trend. The peak number of common loons recorded has varied from a low of 7 in the 1940s to a high of 49 in the 1950s.
Green-winged Teal (*Anas crecca*)	Has increased since the 1940s from 20 to 462.
American Black Duck (*Anas rubripes*)	Has steadily declined since the 1940s when a peak of 1,800 was observed.
Mallard (*Anas platyrhynchos*)	Has increased dramatically between the 1930s and the 1990s from vritually none to 133
Red-breasted Merganser (*Mergus serrator*)	Has steadily increased since the 1930s.
White-winged Scoter (*Melanitta fusca*)	Has dropped sharply from 1,400 during the 1930s to 267 during the 1950s. Peak numbers in the 1990s are similar to those of the 1950s.
Black-bellied Plover (*Pluvialis squatarola*)	Reached a peak of 1,183 in the 1940s and is at 174 in the 1990s.

Semipalmated Plover (*Charadrius semipalmatus*)	Has been relatively stable since the 1930s.
Greater Yellowlegs (*Tringa melanoleuca*)	Reached a peak of 310 during the 1940s then dropped to only 22 during the 1950s. Numbers at 93 in the 1990s.
Semipalmated Sandpiper (*Calidris pusilla*)	Has declined from about 4,500 during the 1930s to approximately 1,180 in the 1990s.
Bonaparte's Gull (*Larus philadelphia*)	Was slightly lower in the 1990s compared to 1930-1950.
Common Tern (*Sterna hirundo*)	Has decreased from 600 in the 1930s to 38 during the 1990s.

> "It is difficult to attribute population trends for birds measured in this report to specific local changes since most of these birds are migratory. In general, there is little evidence that Plum Island Sound as a habitat for birds has changed significantly between the 1930s and today. We do know that ditches, which have been dug throughout the marshes to reduce mosquito breeding habitat, have reduced the number of salt pannes available to birds, and that humans have affected mallard populations by feeding them. We suggest that the changes in the average peak numbers of birds in Plum Island may be related to regional and global factors such as the following.
>
> - Changes in the adequacy of breeding habitat in other regions may impact the bird species that come to Plum Island Sound during the non-breeding season.
> - Shifts in the number and type of fish found in Plum Island Sound caused by overfishing in the Gulf of Maine and other factors may have increased some of the food species available to birds in the Sound.
> - Migratory birds often shift their migration patterns in response to weather conditions and the availability of food" (Buchsbaum et al. 1996).

From the summer of 2000 through the fall breeding season of 2001, the USFWS Parker River Wildlife Refuge along with 15 other refuges are part of a region-wide study to determine shorebird use of impounded wetlands. This study will help determine the varying degree of importance that Refuges contribute to shorebird populations based on geographic location, habitat, and management actions relative to shorebird migration. Four habitat variables are expected to influence shorebird use of impounded wetlands: 1) abundance of an invertebrate food source, 2) mudflat to shallow water depths (since shorebirds are small and need to feed off benthic invertebrates at low tide), 3) slow water draw-downs during the migration period, and 4) sparse vegetation cover within the wetland. Sampling will include shorebird surveys, invertebrate sampling, vegetation density, and water depth. Based on this study, shorebird management plans for the USFWS Parker River Wildlife Refuge will be developed (Drauszewski per comm 2000).

Scientists at the Massachusetts Audubon Society are studying the correlation of salt marsh plant communities with bird species including the Red-Winged Blackbird, Song Sparrow, Sharp-Tailed Sparrow, Common Yellowthroat, Virginia Rail, and Marsh Wren. From vegetation analysis and visual observations of birds at Argilla Road in Ipswich, initial results show: 1) *Phragmites* has no negative impact on bird abundance or density; 2) *Phragmites* has a positive impact on the abundance on Red-Winged Blackbirds; 3) variables other than plant communities have a role in determining the distribution of most species detected; and 4) behaviors may indicate habitat preference where abundance alone does not (Holt per comm 2000).

For additional information on Essex County bird species, occurrences, and habitat see the Passport to Essex County Greenbelt: A Naturalist Guide to Essex County *(1990).*

Rare Species

The Massachusetts Natural Heritage and Endangered Species Program (NHESP), which is part of the Massachusetts Division of Fisheries & Wildlife, is responsible for the conservation and protection of wildlife and plants that are considered rare, threatened, or endangered in the state. Information on the abundance, distribution, and conservation needs of rare species and significant natural communities is collected through field surveys and literature searches by staff biologists and cooperators around the state. Figure 8 illustrates areas that represent the most important natural communities, state-listed rare species habitats, and vernal pools in the ACEC region; Appendix E is a list from the NHESP documenting the rare species found in these areas. For more information from NHESP about rare species lists, reports, and surveys visit their website at *http://www.heritage.tnc.org/nhp/us/ma/.*

The USFWS closes most of the ocean beach side of the Parker River National Wildlife Refuge during the breeding season of piping plovers (April through August). The need to close large sections of the beach during much of the summer to protect these birds is likely to continue for a number of years. Unlike the Wildlife Refuge, The Trustees of Reservation's management of Crane Beach keeps the beach open to the public but ropes or fences off all breeding areas each summer. Both public education and fencing are used as management practices on this beach. Table 9 shows recent trends in piping plover breeding estimates at both beaches.

Table 9. Piping plover breeding estimates (1995-99)

Location	**Crane Beach**		**Parker River National Wildlife Refuge**	
Year	***# pairs***	***# fledge***	***# pairs***	***# fledge***
1995	28	63	21	44
1996	36	33	17	20
1997	27	59	16	20
1998	35	71	15	11
1999	44	89	15	13

Due to consistently high productivity, Crane Beach has long been considered the most important breeding site for piping plovers in New England. In 1999, Crane Beach broke all previous state records for both breeding pairs and numbers of fledglings produced (Castonguay per comm 2000). The productivity decrease of piping plovers on the Parker River National Wildlife Refuge is estimated to be caused by abandonment, predation, washovers, and other weather related incidents (Melvin per comm 2000).

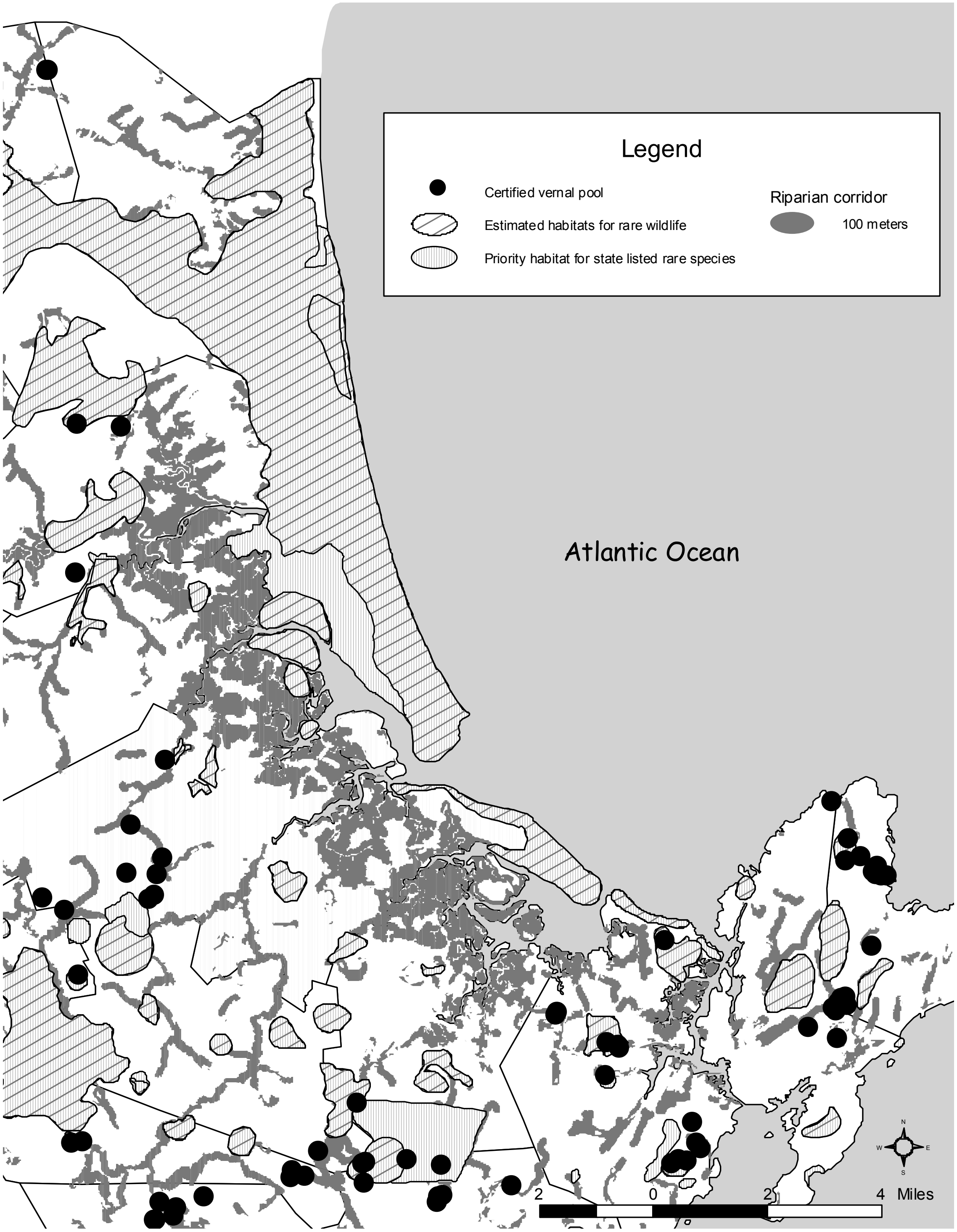

Figure 8. Wildlife habitat: Natural Heritage, vernal pool, and riparian corridor sites

Datalayer Descriptions (source = MassGIS database)

- *Certified vernal pool* = sites are certified by the Natural Heritage and Endangered Species Program.
- *Estimated habitats for rare wildlife* = estimations of resource area habitats of state listed rare wildlife populations in Massachusetts.
- *Priority habitat for state listed rare species* = estimations of the most important natural communities and state listed rare species habitats in Massachusetts.
- *Riparian corridor* = 100-meter corridor encompassing perennial stream and river features.

Wildlife Threats and Habitat Degradation

Much of the ACEC wildlife habitat is either protected under the Massachusetts Wetlands Protection Regulations or is owned by conservation agencies and nongovernmental organizations. However, there is still potential for increased growth and development to impact the upland marsh edge. Research shows that maintaining 300 foot coastal wetland buffers will protect the marsh and enhance habitat values by reducing the amount of wildlife disturbance (Buchsbaum and Purinton 2000). Because much of the ACEC is undeveloped and contains a great deal of conservation land, maintaining wide buffers is still possible in many places. Wildlife corridors along rivers where long stretches of undeveloped, naturally vegetated shorelines still exist and are illustrated in Figure 8. It is important to protect these areas since they provide unfragmented corridors for animal movement (Buchsbaum and Purinton 2000).

Although the ACEC is relatively undeveloped, there are still a number of habitat issues that the region is likely to face in the future, especially as growth and development pressures increase in surrounding communities: decline in water quality and eutrophication, marsh degradation and the continued invasion of *Phragmites*, loss of anadromous fish habitat, fragmentation and loss of wetland buffers and wildlife corridors, vulnerability of barrier beach wildlife, and rising sea level. "Some of these habitat issues are interrelated and are reflections of other regional or even global changes. Others will need to be addressed at the local level" (Massachusetts Audubon Society 1999).

Wildlife Field Notes

The following responses are individual opinions rather than a consensus reached by those interviewed. Field note information can be used by local and regional resource managers to assess research needs, guide restoration efforts, prioritize future workplans, and design technical assistance programs

The following people were interviewed about wildlife populations:

Robert Buchsbaum	Massachusetts Audubon Society
Wayne Castonguay	The Trustees of Reservations
Chris Leahy	Massachusetts Audubon Society
Jim MacDougall	Essex County Greenbelt Association
Deborah Melvin	USFWS Parker River National Wildlife Refuge
Rob Stevenson	Parker River Clean Water Association

1. Based on the information gathered through existing research, have wildlife populations and biodiversity improved or declined in the past 20 years? Where is this trend going in the next 20 years?

- Assessments of the past 20 years vary:
  - Some species have declined while others have prospered. It is difficult to make generalizations about population trends since many migratory species are affected by regional and global impacts. In general, species being properly managed like terns and plovers have increased in the past 20 years, but overall, there has been a regional (not just ACEC) decline in shorebirds.
  - Many groups of wildlife have benefited from increased conservation efforts from federal, state, and private groups to restore avian diversity throughout the Atlantic Flyway.
  - In the past 20 years, biodiversity has decreased as human impacts (roads and housing developments) fragment wildlife habitat and exotic species such as *Phragmites*, green crab, and Japanese shore crab populations increase.
- Projections of the next 20 years include:
  - More plans, programs, and groups working towards sustaining and improving existing populations will likely improve population trends for species being managed. However, as human pressures, habitat fragmentation, and exotic species increase, there will likely be an overall decline in biodiversity.
  - The future of many wildlife populations (especially migratory species) will depend on regional and global conditions that are especially hard to predict. As long as information continues to be gathered about population increases and declines, we will have a better understanding of wildlife, human, and habitat interactions.

2. What additional research and data is needed to improve our assessment of wildlife populations?

- More rigorous, long-term, systematic surveys are needed for shore and migratory bird populations. Existing historic databases include: 1) the U.S. Fish and Wildlife Service monitoring of avifauna trends on the Plum Island Refuge (See Appendix B), and 2) The Trustees of Reservations monitoring of endangered piping plover and tern populations.
- Fact sheets including information for each species, potential threats, and field expert contact information need to be created and stored in a "wildlife information clearinghouse". This information will provide a broader demographic base for each species and a systematic way to maintain and update species information.

- Past research tends to focus on single species rather than ecosystem studies. Although these trends are beginning to change, more emphasis needs to be placed on ecosystem studies, such as the relationship of marsh benthic communities to bird presence and abundance. With salt marsh restoration activities gaining more attention, additional monitoring of plant, invertebrate, and vertebrate responses to these restorations should be well documented as part of an ecosystem study.
- A better understanding about the effects of human impact on wildlife habitats is needed. For example, what are the effects of recreational boating activities on wildlife disturbance, water quality, and bank erosion? What effect does habitat fragmentation (i.e, roads, housing developments, etc.) have on wildlife migration? The effects of salt marsh hay cutting on wildlife habitat which is currently being studied by the Massachusetts Audubon Society and the Woods Hole Ecosystems Center can serve as a model for other human impact and wildlife studies (Woods Hole MBL 1999).
- Many birds have disappeared from the region without a known cause of decline such as American Bitterns, Golden-Winged Warblers, and Common Moorhens. If both long-term wildlife population and human impact studies are combined, we will gain a better understanding for mechanisms causing these types of population declines.

3. What are important threats or issues for wildlife that need to be addressed?

- Increased development on the salt marsh edge where wildlife are sensitive to disturbance.
- Increased development (especially roads) and loss of open space which creates more habitat fragmentation and loss of wildlife corridors.
- Continued recreational boating and beach use and the associated disturbance of shorebird feeding and breeding habitats.
- Endangered species migration to neighboring beaches without management policies (i.e., migrating plovers and terns from TTOR owned Crane Beach to privately owned Wingaersheek Beach).
- Increased cars and domestic pets, which are a direct cause of mortality and disturbance.
- Global and regional impacts of habitat loss and fragmentation, hunting, and lack of migratory route protection.

4. What are opportunities for improvement or restoration of the wildlife populations?

- Increase volunteer opportunities for waterfowl monitoring and habitat restoration projects.
- Continue vigilance for protection of endangered species on beaches.
- Implement boating restrictions on beaches (Wingersheek, Coffins, and Sandy Point) to help manage shorebirds and increase areas of essential breeding/feeding habitats.
- Protect areas between municipal and state owned lands to reduce habitat fragmentation. By identifying linkages and corridors between these areas, wildlife migratory routes can be protected.
- Promote the use of 300 foot wetland buffers for local conservation commission jurisdictional review.
- Increase education and outreach to residents about using their backyards as wildlife habitat (i.e., manicured green lawns are not as good as native plants). This effort will promote a better understanding, awareness, and stewardship of local wildlife and habitats.

FINFISH

The network of tidal creeks in the ACEC are used as spawning, nursery, and feeding areas by many important species of finfish. Forage fishes, such as the sticklebacks and silversides, spawn in emergent salt marsh vegetation; large numbers of winter flounder use marsh creeks for nursery areas; blueback herring and alewives spawn in portions of the upper watersheds (Jerome et al. 1968). Many fish in the ACEC and surrounding waters are migratory, making regular movements between the rivers, estuaries, and ocean (Buchsbaum and Purinton 2000).

For centuries, fish have provided a bountiful source of food, first to Native Americans and then to European settlers in the region. In the seventeenth century, cod, pollock, Atlantic sturgeon, and haddock were the most important exported fish. However as fishing pressures increased with human settlement, finfish abundance decreased. Sharp population declines in the 1730s led to the first fisheries management decision with a closure of the Parker River striped bass fishery in 1771. In the early 1900s, an intense herring fishery caused a serious decline in alewife populations throughout the region. An alewife stocking program, initiated in the Ipswich River in the early 1920s by the Fish and Game Association, transplanted fish from the Essex to the upper Ipswich Rivers. During the late 1930s, sport fishing in the Plum Island Sound region began to increase and is still popular today. Species presently sought by sport fishermen include striped bass, white perch, winter flounder, and smelt (Buchsbaum and Purinton 2000).

The Massachusetts Division of Marine Fisheries (DMF) estuarine monograph series (1968, 1973), the Massachusetts Audubon Society's (MAS) Plum Island Sound Minibay Report (1996), and the Woods Hole Ecosystem Center Plum Island Sound Comparative Ecosystem Study (PISCES) provide assessments of fish populations for the ACEC region. For example, 28 species of finfish were collected by DMF at shore and offshore stations in Plum Island Sound and the Parker River in 1965, while 34 species were collected by the MAS-PISCES study in 1993-1994 (Table 10) (Buchsbaum and Purinton 2000).

Table 10. A check list of finfish species collected at all sampling stations in the Parker River-Plum Island Sound Estuary, 1965 (DMF study) and 1993-4 (MAS-WH study) . The year(s) at which the fish were observed is noted. (Buchsbaum et al. 1996)

Class & Order	Family	Genus & Species	Common Name	Years seen 1965	1993-4
CHONDRICHTHYS					
Squaliformes	Squalidae	*Squalus acanthias*	spiny dogfish	X	
Rajiformes	Rajidae	*Raja erinacea*	little skate	X	
		Raja ocellata	winter skate	X	
		Raja spp.	skate species		X
OSTEICHTHYS					
Acipensiformes	Acipenseridae	*Acipenser oxyrhynchus*	Atlantic sturgeon	X	
Clupeiformes	Clupeidae	*Alosa aestivalis*	blueback herring	X	X
		Alosa pseudoharengus	alewife	X	X
		Alosa sapidissima	shad		X

		Brevoortia tyrannus	Atlantic menhaden		X
		Clupea harengus	Atlantic herring		X
		Opisthonema oglinum	thread herring		X
	Osmeridae	*Osmerus mordax*	American smelt	X	X
	Salmonidae	*Salmo trutta*	brown trout		X
Cypriniformes	Cyprinidae	*Notemigonus chrysoleucus*	golden shiner		X
Anguiliformes	Anguillidae	*Anguilla rostrata*	American eel	X	X
Cyprinodontiformes	Cyprinodontidae	*Fundulus heteroclitus*	mummichog	X	X
		Fundulus diaphanus	banded killifish		X
Gadiformes	Gadidae	*Gadus morhua*	Atlantic cod	X	
		Microgadus tomcod	Atlantic tomcod	X	X
		Urophycis spp..	hake	X	X
Gasterosteiformes	Gasterosteidae	*Apeltes quadricus*	four-spined stickleback	X	X
		Gasterosteus aculeatus	three-spined stickleback	X	X
		Gasterosteus wheatlandi	black-spotted stickleback		X
		Pungitius pungitius	nine-spined stickleback	X	X
	Syngnathidae	*Syngnathus fuscus*	northern pipefish	X	X
Perciformes	Percicthyidae	*Morone americanus*	white perch	X	X
		Morone saxatilis	striped bass		X
	Centrarchidae	*Lepomis macrochirus*	bluegill sunfish		X
	Percidae	*Perca flavescens*	yellow perch		X
	Pomatomidae	*Pomatomus saltatrix*	bluefish		X
	Carangidae	*Vomer setapinnus*	moonfish		X
	Labridae	*Tautogolabrus adspersus*	cunner		X
	Ammodytidae	*Ammodytes americanus*	American sand lance	X	X
	Cottidae	*Hemipterus americanus*	sea raven	X	
		Myoxocephalus octodecemspinousus	longhorn sculpin	X	
		Myoxocephalus	grubby		X

		aenaeus			
	Cyclopteridae	*Cyclopterus lumpus*	lumpfish	X	X
	Anarhichadidae	*Anarhichus lupus*	Atlantic wolffish	X	
	Zoarcidae	*Macrozoarces americanus*	ocean pout	X	
	Atherinidiae	*Menidia menidia*	Atlantic silversides	X	X
	Pholidae	*Pholis gunnellus*	rock gunnel		X
Pleuronectiformes	Bothidae	*Scopthalmus aquosus*	windowpane	X	X
	Pleuronectidae	*Limanda ferruginea*	yellowtail flounder	X	
		Pleuronectes americanus	winter flounder	X	X
Lophiformes	Lophiidae	*Lophius americanus*	goosefish	X	

There were significant differences between the 1960's and 1990's fish assessments in Plum Island Sound. The average catch per unit effort of fish caught by beach seining was about six times higher in early 1990s compared with 1965. The dramatic increase in fish catch is attributable to a five-fold increase in mummichogs and an eleven-fold increase in Atlantic silversides, the two most common species in both studies (Buchsbaum et al. 1996). Reasons for differences between the two studies could include: 1) differences in sampling methodology, 2) differences in physical parameters, 3) random fluctuations, 4) local changes in the ecosystem, 5) changes in pesticide use, and 6) changes in predator numbers (Buchsbaum et al. 1996). Aside from Atlantic silversides and mummichogs, the number of individuals of other species were not different between the two studies.

Major Fisheries and Regional Fish Counts

Striped Bass. The striped bass has been an important commercial and recreational fish species for over a half century. Large numbers of stripers appear in the spring and remain until fall. In the 1980s, striped bass numbers were low along the East Coast as a result of overfishing and pollution of spawning areas. After the implementation of strict management measures that reduced both the commercial and recreational take, their resurgence has been a management success (Buchsbaum and Purinton 2000).

Smelt. Smelt are anadromous fish that spend most of their life in salt water, then migrate up into fresh water to spawn. Historically, abundant populations supported a large number of smelt houses (shelters put on the ice for fishing) through the 1960s. However, populations have plummeted in recent years to the point where there is no longer a winter fishery. Researchers at DMF suggest that algal growth in the upstream spawning habitats is a possible cause of the smelt decline; few eggs are now found (Buchsbaum and Purinton 2000). However, this winter, local recreational fishermen were catching smelt of a good size near the Ipswich town landing. This is the first report of smelt in the Plum Island Sound estuary in recent years (Mountain per comm 2000).

River Herring. River herring (alewives and blueback herring) are also anadromous fish, meaning they are born in fresh water, live for two to three years in the ocean and then return to their original spawning stream to breed. Both alewives and blueback herring are closely related and are hard to distinguish by sight. However, the alewife arrives earlier in the spring and migrates much further up river to breed in headwater ponds, while the bluebacks arrive later and breed in the river current. Juvenile alewives remain in fresh water until later in summer or autumn when they migrate downstream to the ocean (Stevenson et al. 1998).

Historically, the Ipswich River supported a thriving alewife fishery. This fishery was severely impacted due to obstructions on the mainstem of the river and the use of alewife spawning ponds for water supply. Similar to the fish stocking programs in the 1920s, the Massachusetts Department of Fisheries and Wildlife Riverways Program and Division of Marine Fisheries have been working in the 1990s to restore this fishery. This renewed restoration effort has centered on replacing the Sylvania Dam fish ladder and transporting migrating blueback herring from the Charles River to the Ipswich River. It is hoped that the offspring of these transported fish will imprint upon the Ipswich River and return to spawn in the future. To determine if the restoration project is working, the Ipswich Basin Team, Riverways Program, and the Ipswich River Watershed Association are working in partnership to organize volunteer fish counts. The counts are designed to establish sampling to see if, when, and under what conditions the fish are migrating. A total of 53 herring were sighted on 16 different counts with the majority of sightings being between May 14 and May 23, 1999 in the evening hours (IRWA 1999).

From 1997 - 2000 the Parker River Clean Water Association, in partnership with the Essex County Sportsmen's Club, have launched similar volunteer-based fish counts on the Parker River. In the 1970s, runs between 12,000 and 38,000 fish were recorded. However, in the 1997 and 1998 counts, the alewives numbered only 6,396 and 4,242 respectively and in 1999 and 2000, numbers increased to 7964 and 7890. These runs are approximately only 25 percent of that recorded 25 years ago (Stevenson et al. 1998). Possible reasons for decline might be related to changing ocean conditions (where National Oceanic and Atmospheric National Marine Fisheries Survey (NMFS) studies have shown that alewife landings in New England waters have significantly declined in the last 50 years) or loss of spawning habitat in the upper watersheds. In addition to the Ipswich and Parker Rivers, the Essex River also supports an alewife run to Chebacco Lake.

In the Parker Watershed, construction of dams without adequate provisions for fish passage prevent access to historic spawning grounds. Although there are six fishways along the length of the Parker River, many of them are now as much as 70 years old with each being in some state of disrepair (Stevenson et al. 1998). The Parker River Fishway Restoration Action Plan (1998) was written by DMF to provide recommendations for fish passage. The recommendations were based on observations made during several site visits by DMF personnel, as well as an inspection and report prepared by Dick Quinn, Fishway Engineer for the U.S. Fish and Wildlife Service (1997). The purpose of the action plan is to provide a strategy for improvement of fish passage, a priority list for restoration projects, and specific recommendations for maintenance, reconstruction, and alterations to existing structures. *To view a collection of Parker River dam, culvert, and fishway drawings, visit the website http://www.parker-river.org/maps/dams.* Civil engineering students at Tufts University are currently studying the Main Street Dam in Byfield on the Parker River. The students are working to provide alternatives to the current fishway situation including: 1) complete dam removal, 2) installation of two sections of a steep- pass fishway, and 3) lowering the dam by two feet and installing one section of steep-pass. As part of this study, the students will assess the impact of all three alternatives on Parker River hydrology, water quality, aesthetics, and long-term stability.

Waters of the ACEC provide important spawning, nursery, and feeding areas for many finfish species. Although historically finfish populations in the area were of great economic importance, the commercial fisheries markedly declined by the early 1900s and no longer make substantial contributions to the economy of the area. Sport fishing in the area has fluctuated greatly in the past 30 years and depends largely on change in abundance of favored fish (Buchsbaum and Purinton 2000). The watershed association's fish counts help to document change in population abundance as efforts to maintain fishways and investigations of dam removal continue.

Finfish Field Notes

The following responses are individual opinions rather than a consensus reached by those interviewed. Field note information can be used by local and regional resource managers to assess research needs, guide restoration efforts, prioritize future workplans, and design technical assistance programs.

The following people were interviewed about finfish resources:

Robert Buchsbaum	Massachusetts Audubon Society
Chuck Hopkinson	Woods Hole Marine Biological Laboratory
Eric Hutchins	NOAA National Marine Fisheries Service
Rusty Iwanowicz	Massachusetts Division of Marine Fisheries
Rob Stevenson	Parker River Clean Water Association

1. Based on the information gathered through existing research, have finfish populations increased or declined in the past 20 years? Where is this trend going in the next 20 years?

- Without long-term, time-series data, it is hard to adequately assess population trends in the past 20 years. Generally, there has been a decline in anadromous fish populations (alewives and smelt in particular), while small bait fish (mummichogs and silversides), striped bass, and bluefish populations have improved in the last 20 years.
- It is hard to predict population trends in the next 20 years because there are many large-scale issues, such as changing ocean conditions, fishing pressures, and fisheries management practices that will affect ACEC fisheries.

2. What additional research and data is needed to improve assessments of finfish populations?

- More long-term, quantifiable estimates of pelagic species including bluefish, striped bass, winter flounder, and herring are needed. To specifically assess the health of ACEC fisheries, more resources should be allocated to monitoring winter flounder and alewives, which are better local indicators than striped bass or bluefish whose populations reflect larger scale, regional impacts of climate change, overfishing, etc. Both the Plum Island Sound Minibay project and the Woods Hole Ecosystems Center seine and trawl experiments provide data to assess shore fish populations, while the watershed association's volunteer fish counts are a useful model for collecting long-term, quantifiable evidence for herring populations.
- Reasons for the smelt decline need to be researched (i.e., is algal growth in spawning areas causing a decline in smelt populations?). Currently, observational evidence and institutional memory from fishermen exists, but no quantifiable results of smelt populations have been collected.
- More education and outreach about the dependence of juvenile fish on salt marsh habitats and the effects of eutrophication on fish spawning habitats is needed.
- Education and outreach about the connection between inshore and offshore fisheries is needed. For example, since the estuary is acting as a nursery for offshore species, there is more incentive to manage inshore waters properly because these areas impact larger system dynamics.

3. What are the most important threats or issues that need to be addressed for finfish populations?

- Loss of salt marsh due to tidal restrictions and habitat degradation, which reduces the amount of habitat for juvenile and spawning fish populations.
- Water withdrawals, especially in the Ipswich and Parker Rivers during summer drought conditions, which reduce the necessary flow of water needed to maintain healthy fish populations.
- Historic fish ladders in need of maintenance and upgrades.
- Loss of riparian vegetative cover along stream banks caused by increasing development and habitat degradation.

4. Where are opportunities for improvement or restoration of the finfish populations?

- Increase the amount of fish habitat by restoring tidally restricted salt marsh.
- Continue to maintain and upgrade regional fish ladders.
- Continue investigations of dam removal where conditions are favorable.
- Continue doing shoreline surveys to target riparian areas in need of restoration; special attention should be paid to maintaining tributary spawning habitats.
- Plant submerged aquatic vegetation such as eelgrass to increase shoreline habitat.

SHELLFISH

Historically, both Plum Island Sound and Essex Bay have been major shellfishing areas with six species being harvested in the region: soft-shell clam (*Mya arenaria*), surf clam (*Spisula solidissima*), blue mussel (*Mytilus edulis*), razor clam (*Enis directus*), oyster (*Crassostrea virginica*), and ocean quahog (*Arctica islandica*) (*for a detailed account of locations and economic characteristics of each species see Buchsbaum and Purinton 2000*). The distribution of shellfish is partially determined by the tidal flat grain size. Since medium grain sands tend to shift more often than fine grain sands, larger populations of shellfish are generally found in the fine grain sand conditions between high and low water (*for current maps of shellfish bed types and locations, see Appendix C to contact the Merrimack Valley Planning Commission*). Predators of the soft-shell clam include: moon snails or cockels (*Lunatia heros*), horseshoe crabs (*Limulus polyphemus*), the Herring Gull (*Larus agentatus*), the Great Black-Backed Gull (*Larus marinus*), and the green crab (*Carcinus maenus*) (Buchsbaum and Purinton 2000). Historically predation by the green crab was considered a major threat, and today it is again a concern of clammers throughout the ACEC.

Native Americans and early settlers found the soft-shell clam to be a vital source of food, while commercial fisherman used it to support a bait industry for the Grand Banks fishery in the early 19^{th} century (Roach 1992). However, in the late 19^{th} century, over harvesting caused the resource to decline and led to local control of harvesting practices in Ipswich and Essex. Pollution forced the closure of many shellfish beds during the 1920s by the Massachusetts Department of Public Health. Although over harvesting, predation, and natural mortality have depleted the resource through time, statistics indicate that landings have varied greatly from year to year and town to town. For example, in 1945 a combination of over harvesting and high predation rates caused the Ipswich clam industry to be severely depleted (Buchsbaum and Purinton 2000), while in 1949 and 1950, Essex was the leading producer of soft shell clams in Massachusetts. By the 1960s, the shellfish industry in Plum Island Sound recovered to be highly productive as the flats accounted for over half the soft-shell clam harvest in Massachusetts (Jerome et al. 1968).

As of 1984, 1,691 acres of clam flats were estimated to be available for clamming in Plum Island Sound (Buchsbaum et al. 1996) *(see Appendix D for maps of shellfish bed names and locations in Plum Island Sound and Essex Bay*). Based on 1992-1993 data, the total annual value of all bivalves harvested (including soft shell clams, mussels, razor clams, and surf clams) in the Sound was estimated to be $3,345,840. Although numbers vary on a town-by-town basis, Ipswich historically has the highest harvest rates. In 1964, 15,811 bushels were harvested with a value of $134,000 ($8.50/bu.), while a total of 15,400 bushels valued at $924,000 ($60.00/bu.) were taken by commercial Ipswich shellfishermen in 1990 (Jerome et al. 1968, Buchsbaum et al. 1996). Although roughly the same amount of shellfish were harvested, the value increased almost seven times in 30 years (*for detailed historical shellfish investigations of Newbury, Rowley, Ipswich, and Essex see the Jerome, 1968 and Chesmore, 1973 DMF Monographs*).

Although the soft-shell clam is still the most important economic fishery and supports a community of harvesters, distributors, processors, and restaurant owners in the ACEC region, pollution continues to hurt the modern shellfish industry. In Massachusetts, DMF has responsibility for monitoring waters above shellfish beds for fecal coliform bacteria to determine whether shellfish are safe to eat. DMF samples and classifies shellfish harvesting areas according to requirements of the National Shellfish Sanitation Program (NSSP) guidelines (Table 11).

Table 11. DMF classification of shellfish beds in Massachusetts (Roach per comm 2000)
Approved. Suitable for human consumption. Sanitary surveys complete, monitoring indicates low levels of fecal coliform bacteria averaging less than 14 fecal coliform bacteria per 100 ml of seawater with no more than 10 percent of the samples higher than 43. **Conditionally Approved**. Approved for shellfishing, except during intermittent and predictable pollution events such as rainfall or sewage system overflows. These beds require detailed water quality monitoring during rainfall events. Seasonally approved shellfish beds fall within this category and are often closed during the summer because of higher human activity from residents and tourists. Considerable water quality monitoring is required under this classification when the area is open and available for harvest. Shellfish in conditionally approved areas are suitable for human consumption only during approved periods. **Conditionally Restricted**. Areas that are affected by intermittent and predictable pollution events, and meet "restricted" area criteria when a pollution event is not occurring. Fecal coliform concentrations averaging between 14 to 88 per 100 ml seawater with no more than 10 percent of the samples greater that 260. Beds are closed after a rainfall of .5 inches or more (this value is likely to change over time and between growing areas). Shellfish harvested from conditionally restricted areas are not suitable for direct consumption and must be either relayed to an approved area or to a shellfish purification facility and allowed to purge themselves of the pollution over time. These shellfish must be closely monitored and determined to meet strict sanitary standards prior to being marketed for consumption. Shellfish in restricted or conditionally restricted areas can only be harvested by specially licensed commercial diggers – recreational harvesting is not allowed. **Restricted**. Averaging between 14 and 88 fecal coliforms per 100 ml seawater with no more than 10 percent of the samples greater than 260. No rainfall component. Following harvest by specially licensed individuals, shellfish must be subject to a suitable and effective treatment process by relaying to clean water or depuration plant. Not suitable for direct human consumption. **Prohibited**. Closed due to fecal coliform levels consistently exceeding 80 fecal coliforms per 100 ml seawater. Not suitable for human consumption. **Management Closure**. This is not an official classification category under the NSSP. Rather, it is an administrative and management procedure that must be approved by the Director of Marine Fisheries to close a shellfishing area. It is used in lieu of the Prohibited classification to distinguish that an area is closed due to a lack of water quality information. Areas placed under a Management Closure are difficult to obtain water quality information from, located offshore, generally not productive, and were not prioritized by coastal communities when DMF first assumed the program. Slowly as the appropriate water quality information is obtained, many of these areas have been reclassified as Approved.

DMF conducts sanitary surveys at a minimum of once every 12 years to determine sources of pollution in waters overlying shellfish beds. The survey and report are updated and kept current through annual and triennial evaluations which continually assess water quality for classification purposes. Field observations by technically trained persons who reliably evaluate pollution sources and associated impacts on growing areas is another critical component of the survey and reevaluation process.

DMF classifies most of Plum Island Sound as Conditionally Approved for shellfishing (Figure 9); this classification means the flats are closed for five days after 0.5 inches of rainfall because stormwater runoff and bacterial counts increase. If more than one inch of rain falls, the flats are closed for at least eight days. During dry weather, results from the Plum Island Sound Minibay study (1996) indicate that bacterial counts for most of the Sound do not exceed the standard for clean shellfish beds (Buchsbaum et al. 1996). Although development and associated water quality pollution has increased in the last 35 years, most new subdivisions in the region are located some distance from the Sound, leaving it buffered from pollutants generated by new development. Roughly the same acreage of shellfish beds in Plum Island Sound are classified as Prohibited now as when DMF did their Monograph Study in 1965 (Buchsbaum et al. 1996).

During the past decade, bacterial pollution of Essex Bay has become increasingly prevalent, resulting in a greater frequency of shellfish bed closures (Figure 10) (Roach 1992). Based on findings from the 1992 DMF Sanitary Survey, the previously assigned Approved classification in many areas is no longer applicable and now requires a classification downgrade to Conditionally Approved. Survey results found that rain events and subsequent bacterial loadings are "much more complex with far more serious public health implications than originally presumed" (Roach 1992). Essex Bay is now classified as Conditionally Approved with areas closed to shellfishing five days in the winter with 0.75 inches of rainfall and in the summer with greater than 0.4 inches of rain. Pollution source mitigation by the towns of Essex and Ispwich has allowed middle portions of the Castle Neck River to be reopened under a Conditionally Approved classification in January, 1999. Upper portions of Walker Creek, and Essex River are all classified as Prohibited (Roach 1992).

There is hope that water quality and shellfish closures will gradually improve with ongoing pollution abatement programs in the ACEC. For the past decade, Ipswich has made a conscientious effort to control coastal pollution and protect its shellfishing resources. In 1991, The Ipswich Shellfish Advisory Board reported that high levels of fecal coliform seriously affected recreational and commercial shellfishing. In response to this report, the Board of Selectmen created the Ipswich Coastal Pollution Control Committee (CPCC) to develop a Coastal Pollution Management Plan. After three years of research, the CPCC wrote a final report that focused on coastal pollution remediation and incorporated recommendations to the town. In 1999, CZM funding allowed the town to hire a temporary planning assistant to help implement these recommendations (Keane 1999). In the fall of 1999, shellfish beds opened in Fox Creek and Treadwell Island Creek due to successful water quality remediation efforts by the town of Ipswich. The flat openings were an historic event as parts of the Ipswich River have been closed to shellfishing for 74 years and some flats have not been dug for 15 years (Kuhn 1999).

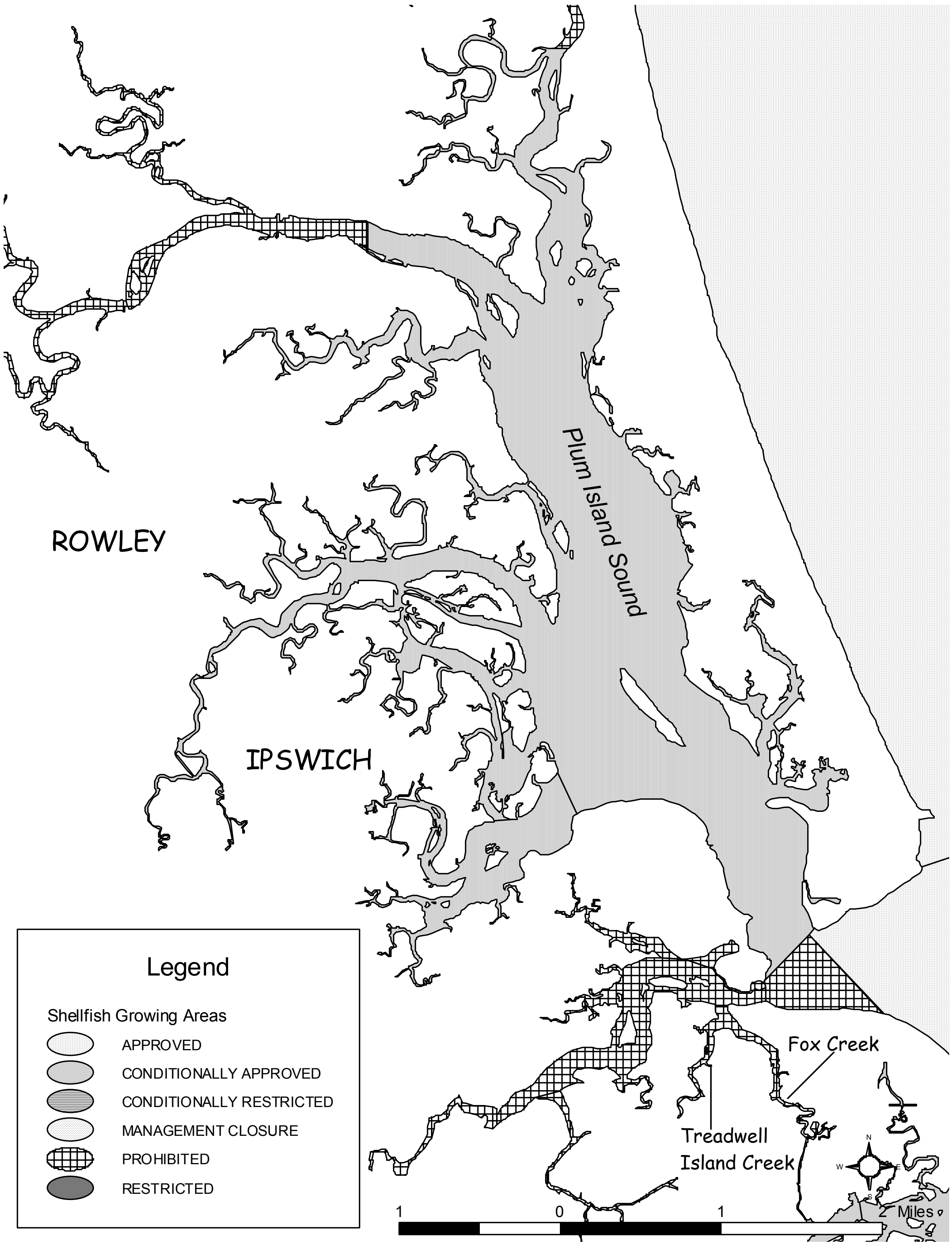

Figure 9. DMF designated shellfish growing areas in Plum Island Sound (April, 1998)
NOTE: Conditionally Approved classification upgrades at Fox and Treadwell Island Creeks in October, 1999 do not appear on this map

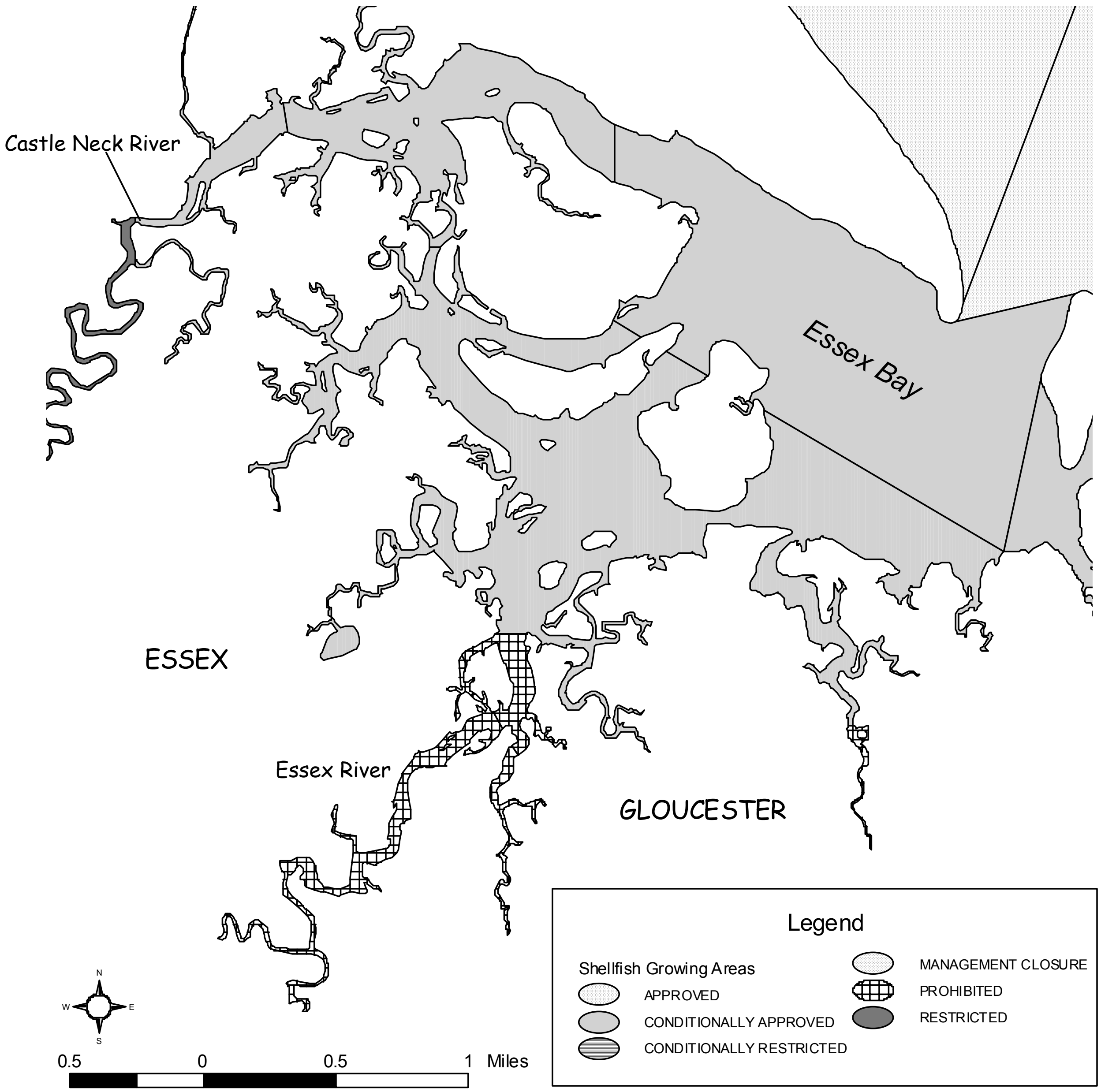

Figure 10. DMF designated shellfish growing areas in Essex Bay (April, 1998)
NOTE: Conditionally Approved classification upgrades for middle portions of the Castle Neck River in January, 1999 do not appear on this map

In Essex, years of water quality data have shown problems with septic system failures. In the late 1990s, the town began addressing the need to create some form of sewage collection and treatment beyond the use of septic systems (Dames and Moore 1999b). In March, 2000 the Gloucester City Council agreed to allow Essex to hook up to the city's sewer system (Mandarini 2000). With this plan in place, water quality in Essex Bay and impacts on shellfish resources are expected to improve *(see the Water Quality section for more information)*.

A multi-year shellfish aquaculture research project was launched on the North Shore in 1995 by a partnership of the Merrimack Valley Planning Commission, Eight Towns and the Bay, the Northeast Massachusetts Aquaculture Center, and the towns of Gloucester, Ipswich, and Rowley. The project goal is to research the feasibility of rearing soft-shell clams for both private aquaculture and public stock enhancement by investigating two techniques of hatchery production and wild seed (or young clam) harvesting. The hatchery component is working to develop a soft-shell clam hatchery at the Aquaculture Center at Salem State College (Castonguay 1999). This research will lead to the development of a critically needed, reliable, and local source of seed. The wild seed harvesting component is exploring ways to "catch" naturally produced seed in the wild to determine if this is a viable alternative to hatchery produced seed. Several types of experimental seed catching nets have been deployed at eight locations in Ipswich, Rowley, and Gloucester. The nets function by allowing clam larvae in the water column to settle and grow under the nets, while protecting them from predators. Based on previous research, it is expected that the nets will capture and protect many thousands of naturally produced young clams that would otherwise perish due to predation and other types of mortality. These clams can then be thinned and the excess transplanted to underproductive or non-productive shellfish areas (Castonguay 1999).

The introduction of exotic marine species, through sources of shipping ballast waters, hull fouling, aquaculture, or aquarium trade, is a threat to the biodiversity in many coastal areas. On the North Shore, biologists are becoming more concerned about invasive populations of green crab, Japanese shore crab, orange tunicates, and European oysters. In many cases, the invaders are able to out-compete native species for food or space and may carry parasites that are harmful to local populations. Organizations such as DMF, CZM, and the Massachusetts Audubon Society are studying the impacts of invasive species on the ecology of coastal waters on the North Shore (Blake 2000). CZM is beginning to identify ways of evaluating biodiversity and ecosystem effects from invaders through a state-wide project that will: 1) conduct a systematic field survey of marine invaders in coastal habitats, especially harbors, ports, and marinas, 2) use this information to evaluate potential sources and impacts, and 3) develop a state management plan for preventing, mitigating, and controlling non-indigenous marine introductions.

Shellfish Field Notes

The following responses are individual opinions rather than a consensus reached by those interviewed. Information does not necessarily reflect the views or policies of each respective agency/organization. Field note information can be used by local and regional resource managers to assess research needs, guide restoration efforts, prioritize future workplans, and design technical assistance programs.

The following people were interviewed about shellfish resources:

Robert Buchsbaum	Massachusetts Audubon Society
Wayne Castonguay	The Trustees of Reservations
Jeff Kennedy	Massachusetts Division of Marine Fisheries
Phil Kent	Ipswich Shellfish Constable
Stubby Knowles	Gloucester Shellfish Constable
Dave Roach	Massachusetts Division of Marine Fisheries
Dave Sargent	Gloucester Shellfish Advisory Board

1. Based on the information gathered through existing research, have shellfish populations increased or declined in the past 20 years? Where is this trend going in the next 20 years?

- Shellfish populations have natural boom/bust cycles that are dynamic and unpredictable. Although it is hard to estimate past resource trends and forecast future trends, *shorter* boom and *longer* bust cycles may be due to cumulative impacts of over harvesting and predation over the past 20 years.
- In the next 20 years, the boom and bust cycles will depend a lot on the economy and market price. In a poor economy, clamming pressures will increase as more people find alternative ways such as shellfishing to make money. If the market price remains high, continued over harvesting combined with a noticeable increase in green crab populations will cause greater cumulative damages to shellfish populations. However, in the next 20 years, longer rainfall closures from increased land-based pollution may serve as a conservation tool that limits harvest pressures.

2. What additional research and data is needed to improve our assessment of shellfish resources?

- *Qualitative* information needs to be gathered about: 1) population impacts from harvesting and green crab predation, 2) seasonal shifts in species size, and 3) effects of pesticides, herbicides, and heavy metal pollutants.
- *Quantitative* information about population estimates, density, location, recruitment, productivity, and mortality needs to be gathered through systematic survey. However, it is hard to track all the variables that influence shellfish populations; where seed settles, creek bottom formations and currents, the type of winter, predation, and harvesting make it hard to estimate quantitative results. Since numbers can change dramatically, it might be more useful to collect data about estuarine sedimentation and flushing characteristics, which directly influence shellfish populations.
- Shellfish Constables submit annual catch reports to DMF on the number of commercial and recreational licenses issued, catch estimates and value, shellfish species, and harvest method. If a database were set up to collect and organize this information, these catch reports would help improve quantitative estimates.
- Additional research is needed for potential effects and impacts of aquaculture practices in the region.
- Research on the effects of recreational boating on shellfish populations is needed.

3. What are important resource threats or issues that need to be addressed for shellfish resources?

- As the number of commercial permits being allocated increases, shellfish over harvesting becomes an issue. Although towns develop their own municipal shellfish program best suited to meet their needs and resources, some beneficial regional approaches could be developed to address the resource decline. Regional strategies might include: 1) collective purchasing of propagation and seeding materials/equipment/supplies in order to leverage the lowest costs for each community and 2) coordination of a regional predator control program, particularly for green crabs.
- With greater development in the upper and lower watersheds, nonpoint source pollution will likely increase and it will be harder to maintain or improve the DMF shellfish classifications from Prohibited or Restricted to Conditionally Approved. However, pollution trends will largely be dependent on local commitment to identifying sources, mitigation work, and proper planning for future development. Recent efforts have already allowed upgrades in shellfish classifications. Thus, it is important to continue implementing agricultural and stormwater Best Management Practices, such as holding basins or vegetated swales if shellfish harvesting is to continue at the same or an improved rate.
- As recreational boating is becoming more popular in Plum Island Sound and Essex Bay, wastewater, petroleum products, and increased turbidity will impact shellfish populations.
- Increasing green crab populations will continue to stress shellfish populations.

4. What are opportunities for improvement or restoration of shellfish resources?

- Continue using information from DMF shoreline surveys to target land-based water quality hot spots and promote wastewater management.
- Promote the Ipswich CPCC report and use of a planning assistant to implement water quality remediation and shellfish management recommendations as a model to other ACEC towns.
- Continue researching the establishment of shellfish hatcheries and seeding experiments as potential restoration and aquaculture models for the region. Pilot seeding experiments currently underway in Gloucester, Rowley, and Ipswich that are being monitored for their success and challenges can be used as models throughout the region.
- Reduce over harvesting by setting limits on the number of commercial permits issued during times of high market price or by lowering the take allowed for each harvester. An alternative to harvest reduction is to focus more attention on shellfish seeding programs which help maintain the resource.
- Decrease exotic species and harvest pressures on shellfish populations by finding viable green crab markets.
- Allocate more staff and money to local shellfish constables. Much of the restoration work such as harvest enforcement, predator reduction, and seeding programs depend on the amount of time these officials spend in the field.
- Create a more reliable data collection system. For example, data obtained from DMF “shellfish transaction cards” should be cross-checked with data that shellfish constables and individual harvesters submit. This system would promote greater accountability among harvesters and increase the reliability of data collected for quantitative and qualitative estimates (i.e., shellfish bed locations, population densities, and species compositions). Implementing a better system to collect shellfish information will also provide data needed to put water quality remediation projects into economic terms. The greatest obstacle to setting up a database to collect this information is funding.